(54) **DSL transmission system with far-end crosstalk compensation**

(57)   The invention relates to a far-end crosstalk (FEXT) canceling circuit for a digital subscriber line transmission system, said transmission system comprising a plurality n of line termination (LT) modems (Mi) transmitting discrete multitone (DMT) symbols Si to corresponding network (NT) termination modems (Mc(i)) over n transmission channels.

The invention proposes to multiply the vector S = (Si) i = 1 to n, before transmission, by a precompensation matrix M such that the matrix product H*M is diagonal, H being the transfer matrix of the n downstream transmission channels defined by R = H*S where R = (Ri), i = 1 to n, is the vector of the DMT symbols Ri respectively received by the modems Mc(i)
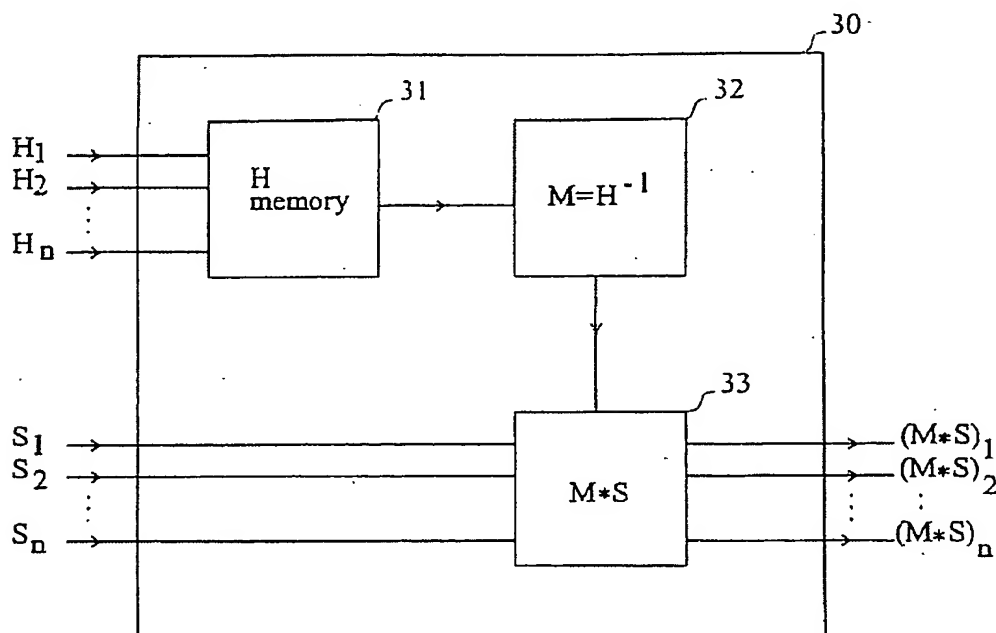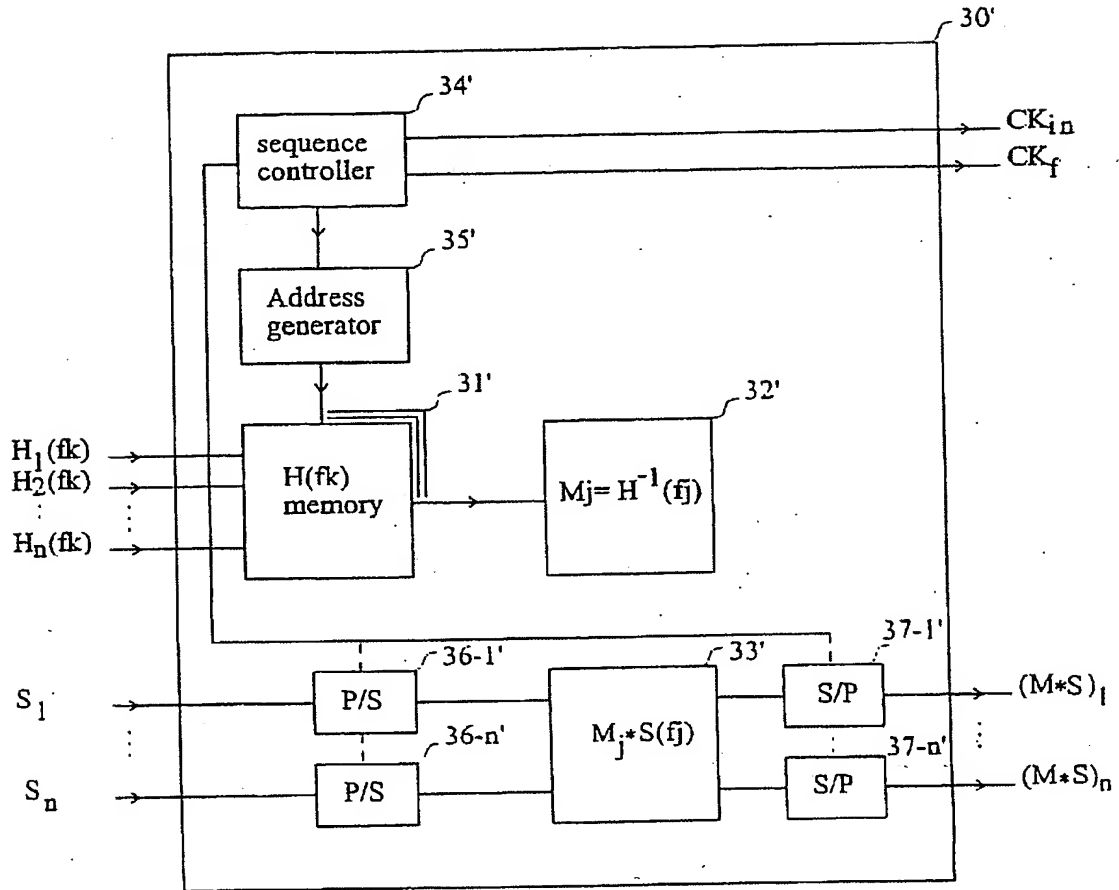
Fig 3A

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Fig 3B

Description

FIELD OF THE INVENTION

[0001]   The present invention relates to digital sub-
scriber line transmission systems, which allow, in par-
ticular high speed communication on twisted pair tele-
phone lines based on discrete multitone transmission
(DMT) The invention relates more specifically to a far-
end crosstalk (FEXT) canceller for compensating the
crosstalk signal induced by modems located at the far-
end of such a transmission system

DISCUSSION OF THE RELATED ART

[0002]   Figure 1 schematically shows a modem, com-
prising a transmission (TX) and a reception (RX) section
in a conventional DSL transmission system using digital
multitone. A serial stream of data X is provided to a map-
per circuit 11 mapping each data into a symbol of a con-
stellation, for example of a QAM (Quadrature Amplitude
Modulation) constellation. The mapped values are then
transformed into a set S of N components by a serial to
parallel converter 12, each component of the set being
considered as a frequency domain coefficient This set
of frequency domain coefficients, hereafter also called
DMT symbol, is provided to an inverse fast Fourier
transform (IFFT) circuit 13 which generates a time do-
main block of samples and is followed by a parallel/serial
converter (P/S). This time domain block is therefore the
sum of N sinusoidal subcarriers of different frequencies,
the amplitude thereof being determined by the corre-
sponding frequency domain coefficient received by the
IFFT circuit.

[0003]   Each time domain block is cyclically prefixed
(cp) and suffixed (cs) in a block 19 to suppress or at
least attenuate the Inter Symbol Interference (ISI) and
the Inter Carrier Interference (ICI) caused by the chan-
nel, and is transmitted onto a telephone line 10 through
a hybrid line interface 18. The line interface 18 also re-
ceives incoming time domain blocks from another mo-
dem connected to line 10

[0004]   At the receiving side, the incoming time do-
main blocks from line 10 are provided to a fast Fourier
transform (FFT) circuit 14 through a block 19' that de-
letes the prefix and suffix and a serial/parallel converter
(S/P) which calculates the N frequency domain coeffi-
cients for each block The N frequency domain coeffi-
cients are then provided to an equalizer 15 which com-
pensates for the attenuation and phase shift incurred by
each frequency component The equalized values are
then serialized by a parallel to serial converter 16 into a
stream of N complex numbers $R(f_j)$ and then processed
by a demapper 17 attributing for each $R(f_j)$ the symbol
$\hat{S}c$ of the constellation which comes closest thereto The
demapper 17 further outputs the digital word $\hat{X}c$ asso-
ciated with the selected constellation point $\hat{S}c$

[0005]   Figure 2 schematically shows a DSL transmis-

sion system comprising a central office 20 communicat-
ing with a plurality of end-users over telephone lines 25.
26 The modems M1, M2, Mc(1), Mc(2) have the struc-
ture represented in figure 1 The end of a telephone line
connected to a modem of the central office is called the
line termination (LT) side while the end connected to a
modem of an end-user is called the network termination
(NT) side

[0006]   Ideally, such a DSL transmission system al-
lows the whole frequency band to be used for simulta-
neous full-duplex transmissions. However, in practice,
different sources of noise disturb the transmissions and
impede proper reception of data

[0007]   For a given modem, three different sources of
noise can be distinguished as illustrated on figure 2:

- the self-echo, I e for a given modem, the parasitic
  signal from the transmitter TX leaking to the receiv-
  er RX through the hybrid interface;

- the near-end crosstalk (NEXT) arising from signals
  in adjacent telephone lines 25, 26 with opposite
  transmission directions More specifically, in the
  present example, the NEXT generated at the mo-
  dem Mc(1) is the parasitic signal received by this
  modem from the modem Mc(2). In this instance the
  NEXT is called NT-NEXT because the modem Mc
  (1) is located on the NT side Reciprocally, the
  NEXT generated at modem M1 by the modem M2
  is called LT-NEXT;

- the far-end crosstalk (FEXT) arises from signals
  traveling along the same transmission direction in
  adjacent telephone lines More precisely, in the il-
  lustrated example, the FEXT generated at the mo-
  dem Mc(1) is the parasitic signal received by this
  modem from the modem M2 located on the opposite
  side, due to the coupling between the telephone
  lines 25 and 26 sharing a common binder. In this
  instance the FEXT is called NT-FEXT because the
  modem Mc(1) is located on the NT side Recipro-
  cally, the FEXT generated at modem M1 by the mo-
  dem Mc(2) is called LT-FEXT

[0008]   Echo cancellers for canceling self-echoes are
known, e g from unpublished European patent applica-
tion N° 98410112 filed by the applicants This document
is however to be taken into account as prior art only un-
der Art 54(3) EPC

[0009]   There is also known from US-A-5887032 a
canceller for canceling out the NEXT interference in an
ADSL transmission system on the LT side This cancel-
ler operates in the frequency domain and assumes, for
a given subcarrier or tone, that the NEXT interference
is proportional to the symbol value emitted by the mo-
dem transmitting on the interfering channel The latter
value is scaled by a given coefficient and subtracted
from the symbol received by the modem suffering from
the NEXT interference

[0010]   Both self-echo cancellation and LT-NEXT can-

cellation are possible because the signal transmitted by the same modem (in the case of the self-echo) or by a neighboring modem of the central office (in the case of LT-NEXT interference) is directly available

[0011] FEXT cancellation is however intrinsically more complex than NEXT or self-echo cancellation because the modem transmitting over the interfering channel is now located on the far-end side and the actual values of the interfering symbols are therefore not known.

SUMMARY OF THE INVENTION

[0012] An object of the present invention is therefore to design a canceller circuit for a DMT based DSL transmission system capable of significantly removing the FEXT interference and having a simple structure

[0013] It is also an object of the present invention to design an efficient FEXT canceling method in a DMT based DSL transmission system

[0014] These objects are attained by the invention as claimed.

[0015] The foregoing and other objects, features, aspects and advantages of the invention will become apparent from the following detailed description of embodiments, given by way of illustration and not of limitation with reference to the accompanying drawings

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Figure 1, previously described, schematically shows the structure of a modem suitable for use in a DSL transmission system;

Figure 2, previously described, schematically shows the different types of noise occurring in a DSL transmission system;

Figure 3A shows a first embodiment of a FEXT canceller according to the invention;

Figure 3B shows a second embodiment of a first canceller according to the invention;

Figure 4 shows the structure of a modem on the LT side suitable for use with a FEXT canceller according to the second embodiment of the invention;

Figure 5 shows the structure of a modem on the NT side suitable for use with a FEXT canceller according to the second embodiment of the invention; and

Figure 6 shows the overall structure of a DSL transmission system using both an LT-FEXT canceller and an NT-FEXT canceller according to the first or the second embodiment of the invention

DESCRIPTION OF THE INVENTION

[0017] The invention is based on the idea that it is possible to remove FEXT interference at the NT side by appropriately predistorting at the LT side the DMT symbols

to be transmitted More specifically, if S is the vector (Si), i = 1 to n, where Si is the DMT symbol to be transmitted by the modem Mi and if R is the vector (Ri). i = 1 to n, where Ri is the DMT symbol received by the modem Mc (i), then R = H*S where H is the transfer matrix of the n downstream (i e. LT to NT) transmission channels

[0018] R and S are vectors of n*N components as concatenation of n vectors of N components, each Si (resp Ri) being a vector of N frequency (or tone) components Si(fj) (resp Ri(fj))

[0019] If we assume that there exists a matrix M such that H*M=D where D is diagonal and if the vector S is multiplied by the matrix M before transmission then R=H*M*S=D*S is freed from FEXT interference since any component Ri(fj) of the DMT symbol Ri received by the modem Mc(i) depends only upon the component Si (fj) of the DMT symbol Si transmitted by the modem Mi

[0020] In most practical cases, the transfer matrix H can be inverted and one can simply choose $M = H^{-1}$ and D = I, where I is unity matrix This provides a further advantage since equalization of the frequency components of the received DMT symbols is no longer necessary.

[0021] A FEXT precompensating circuit according to a first embodiment of the invention is hereafter described in connection with figure 3A This circuit comprises a memory 31 in which are stored the columns Hi of the transfer matrix H The matrix coefficients Hik are then supplied to a matrix inverter 32 A matrix multiplier 33 receives the inverted matrix $M=H^{-1}$ as well as the DMT symbols Si provided by the LT modems Mi and performs the multiplication M*S. The DMT symbols

$$(M^*S)_l = (M^*S)_{j+(i-1)^*N}, j = 1 \text{ to } N,$$

are then respectively supplied to the LT modems Mi In each LT modem Mi the DMT symbol $(M^*S)_l$ is provided to an IFFT circuit in place of the DMT symbol Si and the resulting time block of samples is transmitted to the NT modem Mc(i)

[0022] As shown in figure 6, the coefficients of the transfer matrix can be provided by an external LT-FEXT canceller 60 such as disclosed in copending European application entitled "DSL transmission system with far-end crosstalk cancellation" filed by the applicants Basically, this LT-FEXT canceller adaptively estimates the inverse H_u^{-1} of the transfer matrix of the n upstream (i. e NT to LT) transmission channels and multiplies the vector of the DMT symbols received by the LT modems by H_u^{-1} for recovering FEXT-free received symbols Assuming that the downstream transfer matrix $H = H_u^{-1}$, the FEXT precompensating circuit 61 can directly use the estimated matrix output by the LT-FEXT canceller as matrix H

[0023] When there is no symmetry, one can also estimate H^{-1} or H, respectively H (fj)$^{-1}$ or H(fj) as mentioned hereafter. by an adaptive algorithm minimizing

a quadratic error (for example by a least mean square method) The method consists in calculating the error

$$e_k^2 = \|R_k - \hat{S}_k\|^2 = \|(H \ \hat{H}^{-1} \cdot S)_k - \hat{S}_k\|^2$$

on the NT side and in sending back this error to the LT side for updating the coefficients of $\hat{H}^{-1}$ (here, k is not the time index but a specific value of S)

[0024] A second embodiment of the FEXT precompensating circuit is hereafter described in connection with figure 3B.

[0025] In a conventional DMT transmission system, the FEXT generated at a frequency fj depends also upon frequency components transmitted at neighboring frequencies since the limited duration of the time domain blocks causes a spreading of the frequency components It is now assumed that the FEXT generated at a frequency fj depends only upon components transmitted at the same frequency (intra-frequency FEXT)

[0026] If the modems are synchronous Zipper modems as described in the international application WO97/06619, the assumption made above is fully valid, i.e the FEXT at a frequency fj is independent from the frequency components transmitted at the frequencies fi, i≠j Indeed, in such modems, the suffix appended to each time domain block before transmission eliminates any inter-frequency crosstalk

[0027] With the intra-frequency crosstalk assumption the matrix calculations are simplified: if the components at each frequency fj of the DMT symbols Si (resp. Ri) in vector S (resp. R) are grouped together, the transfer matrix H exhibits the form of a diagonal block matrix with N matrices H(fj) along its diagonal, the intra-frequency crosstalk H(fj) matrices having n*n coefficients The inversion of the matrix H and the multiplication M*S can thus be performed sequentially frequency by frequency

[0028] In this embodiment a sequence controller 34' controls an address generator 35', parallel to serial converters 36-1' to 36-n', serial to parallel converters 37-1' to 37-n', and generates the insertion control clock CKin and the tone clock CKt for all the LT modems i.

[0029] The memory 31' is organized in planes, each plane storing a matrix H(fj) The matrices H(fj) are sequentially retrieved and inverted in matrix inverter 32' The inverted matrices H1(fj) are sequentially provided to matrix multiplier 33'

[0030] The DMT symbols Si are each provided to a parallel to serial converter 36-i' controlled by the sequence controller 34' The N components Si(fj), j = 1 to N, are sequentially output by the parallel to serial converters and the matrix multiplier 33' sequentially calculates the matrix products $H^{-1}(fj)* \ S(fj)$, where S(fj) is the vector S(fj) = (Si(fj), i = 1 to n The components [H⁻¹(fj) *S(fj)]ᵢ of the vector provided by the matrix multiplier 33' are then each transformed by serial to parallel converters 36-i' into DMT symbols (H⁻¹*S)ᵢ

[0031] Figure 4 shows an LT-modem Mi for use with

a FEXT precompensating circuit according to the second embodiment of the invention

[0032] The structure of this modem is similar to the one shown in figure 1. the identical elements bearing translated references After mapping, the complex components are provided to a zero inserter inserting a zero component on a rising edge of signal CKin at a location given by a modulo N counter 422 clocked by the signal CKt The complex components are then converted into a DMT symbol Si by a serial to parallel converter 412 and Si is provided to a precompensating circuit 30' The DMT symbol (H⁻¹*S)ᵢ output by the precompensating circuit is provided to a pilot tone inserter circuit 430 which inserts a pilot tone component P(i,fj) on a rising edge of the signal CKin delayed by the delay 431. The modulo N counter 422 provides the more significative bit (MSB) of a read address to ROM 433, the least significative bit (LSB) of the address being given by a signal SELi which indicates whether the modem is selected This signal can be directly generated by the sequencer or, preferably, provided by a comparator 434 comparating the rank i of the modem Mi with the output of a modulo n counter 432 clocked by Ckin. The data P(i,fj) stored at the read address are supplied to the pilot tone inserter 430 which inserts the pilot tone value P(i,fj) as a component at frequency component fj of the DMT symbol Si on the rising edge of the delayed signal CKin. The DMT symbol is then frequency-time transformed by the IFFT circuit 413 as usual.

[0033] On the receiving side of the modem Mi, the block RX is identical to the block RX of the modem illustrated in figure 1. The data output by RX are provided to a demultiplexer which separates the received coefficients Hik from the data as explained further below.

[0034] In normal transmitting mode the signals CKin and CKt are low, no zero is inserted by the zero inserter 420 and no pilot tone value is inserted by the inserter 430 The data X are normally mapped and the parallelized into DMT symbols Si. The precompensated DMT symbol (H⁻¹*S)ᵢ received from the precompensating circuit 30' is also directly fed to the IFFT circuit.

[0035] In mixed transmitting/updating mode, the zero inserter inserts a zero complex value at the location j given by the counter 422 This is done simultaneously for all the modems Mi Each Si carries therefore N-1 normally mapped data and a zero at the frequency fj All the precompensated DMT symbols (H⁻¹*S)ᵢ received from the precompensating circuit 30' have therefore also a zero as component at frequency fj In each modem Mi, this zero is replaced by the pilot tone inserter with a complex value P(i,fj) = 0 if SELi = 0 ánd P(i,fj) = pj if SELi = 1, where pj is a predetermined complex number depending upon the frequency fj only The modems M1, M2 . Mn are selected in turn at the frequency of CKin A further CKt pulse increments j and the whole insertion process is repeated again at the new frequency fj

[0036] If the current counter value is j0 and if the modem Mi0 is selected. the n components at frequency fj0

of the DMT symbols received by the NT modems Mc(i) constitute the i0-th column of the matrix H(fj0) multiplied by pj0. The NT modems Mc(i) can therefore transmit the matrix coefficients $H_{i0i}(fj0)$ to the LT modems Mi, each coefficient being for example preceded by a predetermined header Demultiplexer 440 in LT modem Mi detects this header and extracts the coefficient $H_{i0i}(fj0)$ The column vector $(H_{i0i}(fj0))$, i = 1 to n, is sent to the precompensating means 30' and stored at the i0-th column of the j0-th plane of memory 31'

[0037]   Figure 5 shows the structure of a NT modem which can be used with the precompensating circuit of figure 3B and LT modems of figure 4 The structure of this modem is similar to the one shown in figure 1, the identical elements bearing translated references In contrast with the latter, the NT modem comprises a multiplexer 520, updating means 530, a modulo N counter 522 and has no equalizer It is assumed that the NT side is provided with a sequence controller synchronized with the controller 34' and having the same sequence pattern

[0038]   The updating means 530 receives a value j0 from the modulo N counter 522 clocked by CKt and the signal Ckin delayed by delay 531 In updating/transmitting mode, the updating means 530 extracts on a rising edge of Ckin the component at frequency j0 of the received DMT symbol output by the FFT block 514 The updating means 530 compares the coefficient $H_{i0i}(fj0)$ with the last coefficient $H_{i0i}(fj0)$ previously obtained If the absolute value of the difference is greater than a given threshold Thj0, which in general is a function of frequency fj0, the new coefficient is appended to a header and transmitted via multiplexer 520 to the LT modem Mi.

[0039]   Turning back to figure 3B, similarly to the first embodiment, the columns of the matrices H(fj) can also be directly provided by an external LT-FEXT canceller as shown in figure 6 With the assumption of intra-frequency FEXT the LT-FEXT canceller has a simplified structure. In such an instance, as disclosed in the above cited copending application, the LT-FEXT canceller estimates the matrices $H_u^{-1}(fj)$ for j = 1 to N These matrices can be used as the precompensating matrices H(fj)

[0040]   Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the spirit and the scope of the present invention Accordingly, the foregoing description is by way of example only and is not intended to be limiting The present invention is limited only as defined in the following claims and the equivalents thereto

Claims

1.   A far-end crosstalk (FEXT) canceling circuit for a digital subscriber line transmission system, said transmission system comprising a plurality n of line termination (LT) modems (Mi) transmitting discrete multitone (DMT) symbols (Si) to corresponding network (NT) termination modems (Mc(i)) over n transmission channels, characterized in that it comprises precompensation means (33, 33') multiplying, before transmission, the vector S = (Si), i = 1 to n, by a precompensation matrix (M) such that the matrix product H*M is diagonal, H being the transfer matrix of the n transmission channels defined by R = H*S, where R = (Ri), i = 1 to n, is the vector of the DMT symbols Ri respectively received by the modems Mc(i).

2.   The FEXT canceling circuit of claim 1, characterized in that it further comprises:

   storing means (31) storing said transfer matrix (H);
   inversion means (32) inverting said transfer matrix and providing the precompensation means (33) with the inverted matrix (H^{-1})

3.   The FEXT canceling circuit of claim 1, characterized in that it further comprises:

   storing means (31') storing transfer matrices H (fj) of the n transmission channels at tones fj, H (fj) being defined by R(fj)= H(fj) * S(fj), where R (fj) is the vector R(fj)= (Ri(fj)) i = 1 to n and S(fj) is the vector S(fj) = (Si(fj)), i = 1 to n, Ri(fj) and Si(fj) being the components at tone fj of the received DMT symbol Ri and transmitted DMT symbol Si respectively; and
   inversion means (32') sequentially inverting said transfer matrices H(fj) and supplying the precompensation means (33') with the inverted matrices $H^{-1}(fj)$, the precompensation means (33') sequentially calculates the products $H^{-1}(fj)$ *S(fj)

4.   A digital subscriber line transmission system comprising a plurality n of line termination (LT) modems (Mi) transmitting discrete multitone (DMT) symbols Si to corresponding network (NT) termination modems (Mc(i)) over n transmission channels, characterized in that it further comprises:

   a FEXT canceling circuit (61) according to claim 1 or 2 canceling FEXT at the NT side of said system; and
   an LT-FEXT canceling circuit (60) canceling FEXT at the LT side of said system by estimating the inverse of the transfer matrix H^{-1}_{up} of the plurality of the transmission channels in the upstream direction, said LT-FEXT canceling circuit supplying the storing means of said FEXT canceling circuit with H= H^{-1}_{up}

5.   A digital subscriber line transmission system comprising a plurality n of line termination (LT) modems

(Mi) transmitting discrete multitone (DMT) symbols Si to corresponding network (NT) termination modems (Mc(i)) over n transmission channels, characterized in that it further comprises:

a FEXT canceling circuit (61) according to claim 3 canceling FEXT at the NT side of said system; and
an LT-FEXT canceling circuit (60) canceling FEXT at the LT side of said system by estimating the inverse of the transfer matrices $H^{-1}up$ (fj) of the plurality of transmission channels in the upstream direction at tone fj, said LT-FEXT canceling circuit supplying the storing means of said FEXT canceling circuit with $H(fj) H^{-1}up(fj)$

6. A digital subscriber line transmission system comprising a plurality n of line termination (LT) modems (Mi) transmitting discrete multitone (DMT) symbols Si to corresponding network (NT) termination modems (Mc(i)) over n transmission channels, further comprising a FEXT canceling circuit according to claim 3 canceling FEXT at the NT side of said system;
characterized in that

each LT modem (Mi) comprises inserting means (430) for inserting at predetermined times known symbols P(i,fj) as components at tone fj of multitone symbols Si;
each NT modem Mc(k) comprises means (530) for detecting at said predetermined times the components Rk(fj) and for deriving therefrom the coefficients $H_{ik}(fj)$ of the transfer matrix H (fj);
each NT modem Mc(k) further comprises a multiplexer (520) for multiplexing data to be transmitted with said coefficients $H_{ik}(fj)$;
each LT modem Mk further comprises a demultiplexer (440) for extracting from the received data said coefficients $H_{ik}(fj)$

7. A far-end crosstalk (FEXT) canceling method for a digital subscriber line transmission system, said transmission system comprising a plurality n of line termination (LT) modems (Mi) transmitting discrete multitone (DMT) symbols Si to corresponding network (NT) termination modems (Mc(i)) over n transmission channels, characterized in that the vector S = (Si), i = 1 to n, is multiplied, before transmission, by a precompensation matrix M such that the matrix product H^*M is diagonal, H being the transfer matrix of the n transmission channels defined by $R = H^*S$, where R = (Ri), i = 1 to n, is the vector of the DMT symbols Ri respectively received by the modems Mc(i)

8. The FEXT canceling method of claim 7, character-ized in that

said transfer matrix is stored in storing means;
said transfer matrix is then retrieved and inverted;
and

the inverted matrix is used as precompensation matrix M

9. The FEXT canceling method of claim 7, characterized in that

the transfer matrices H(fj) of the n transmission channels at tones fj are stored in storing means, H(fj) being defined by $R(fj) = H(fj) * S(fj)$ where R(fj) is the vector $R(fj) = (Ri(fj))$, I = 1 to n, and S(fj) is the vector $S(fj) = (Si(fj))$, i = 1 to n, Ri(fj) and Si(fj) being the components at tone fj of the received DMT symbol Ri and transmitted DMT symbol Si respectively;
said transfer matrices H(fj) are retrieved and inverted;
the inverted matrices $H^{-1}(fj)$ are used as precompensating matrices at tones fj.

10. The FEXT canceling method of claim 9, characterized in that

for each LT modem Mi. known symbols P(i,fj) are inserted at predetermined times as components at tone fj of multitone symbols Si;
for each NT modem Mc(k), the components Rk (fj) are detected at said predetermined times, the coefficients $H_{ik}(fj)$ of transfer matrix H(fj) are derived therefrom and multiplexed with the data to be transmitted;
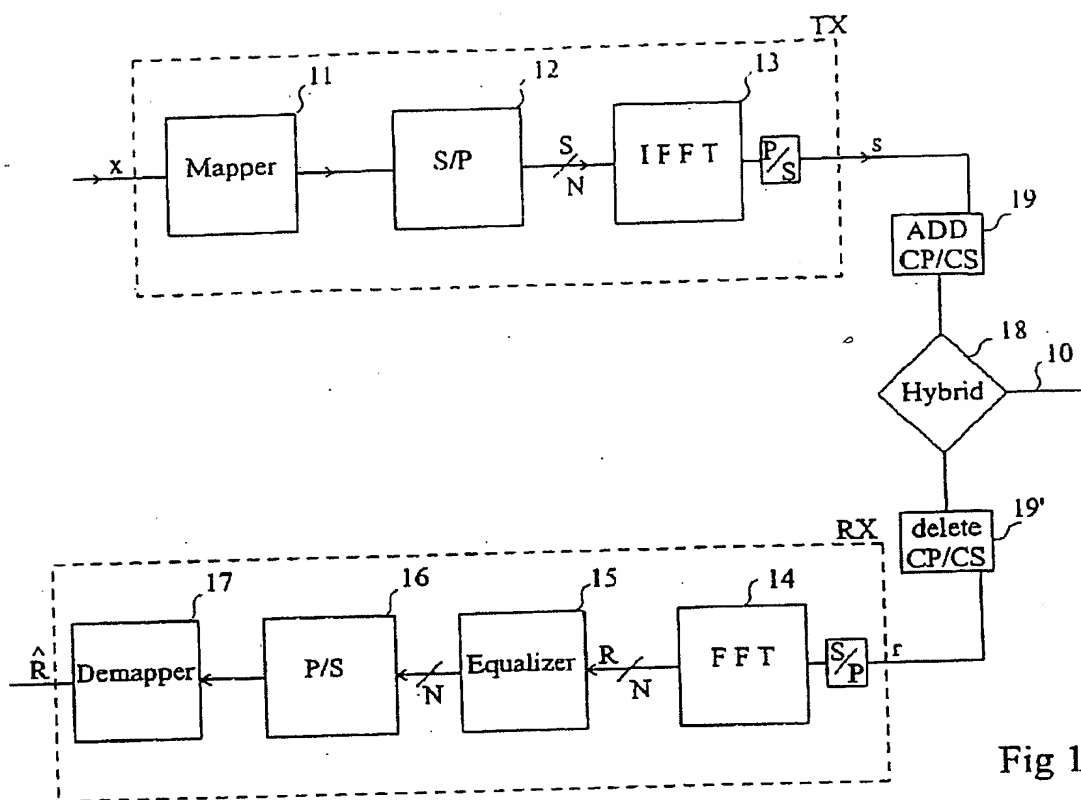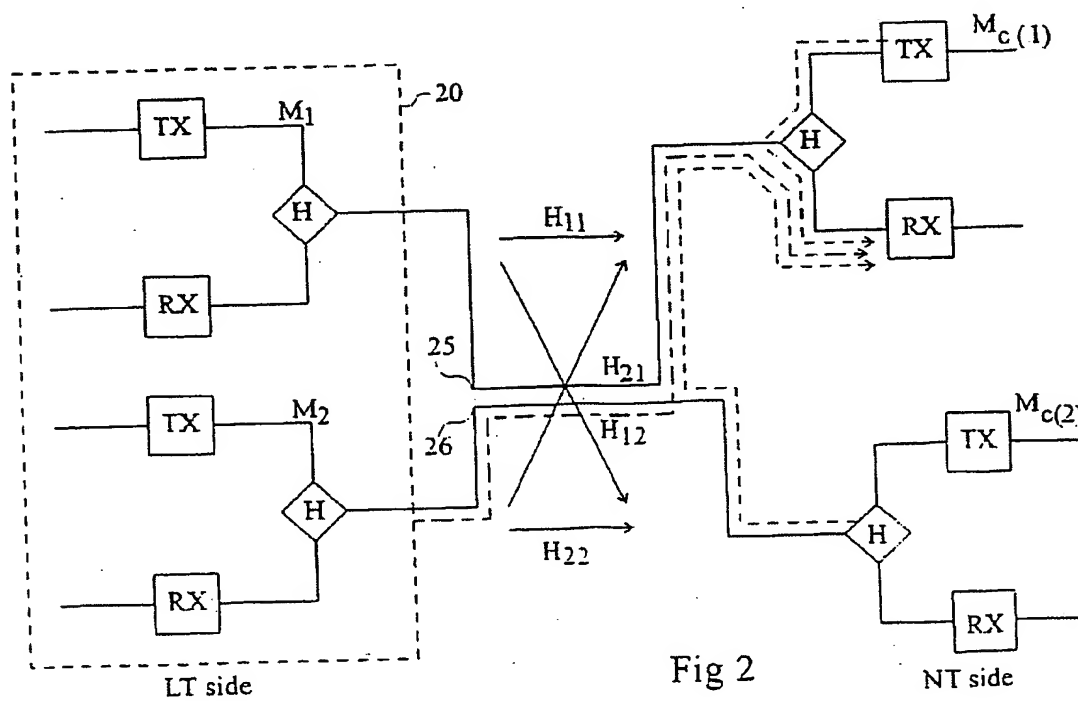for each modem Mk, said coefficients $H_{ik}(fj)$ are extracted from the received data.

Fig 1

Fig 2

LT side
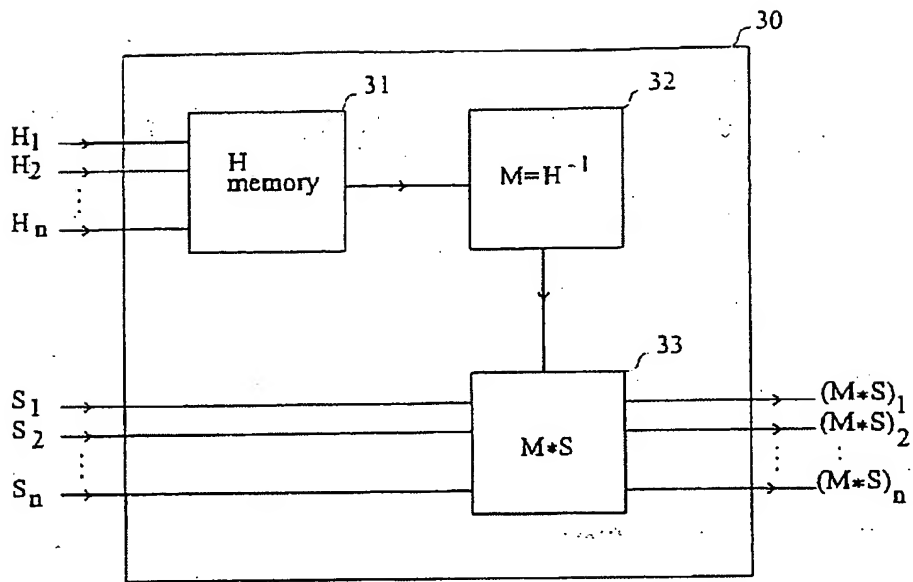
NT side

Fig 3A

Fig 3B

Fig 4

Fig 5

$$\hat{R} \quad X$$

60

$$R_1$$
$$\hat{S}c(1)$$
$$M_1$$
$$S_1$$
$$(H^{-1}_n *R)_1$$
$$(M*S)_1$$

61

LT-FEXT
canceller

NT-FEXT
precompensating
circuit

$$\hat{R} \quad X$$

$$Rn$$
$$\hat{S}c(n)$$
$$M_n$$
$$Sn$$
$$(H^{-1}_n *R)_n$$
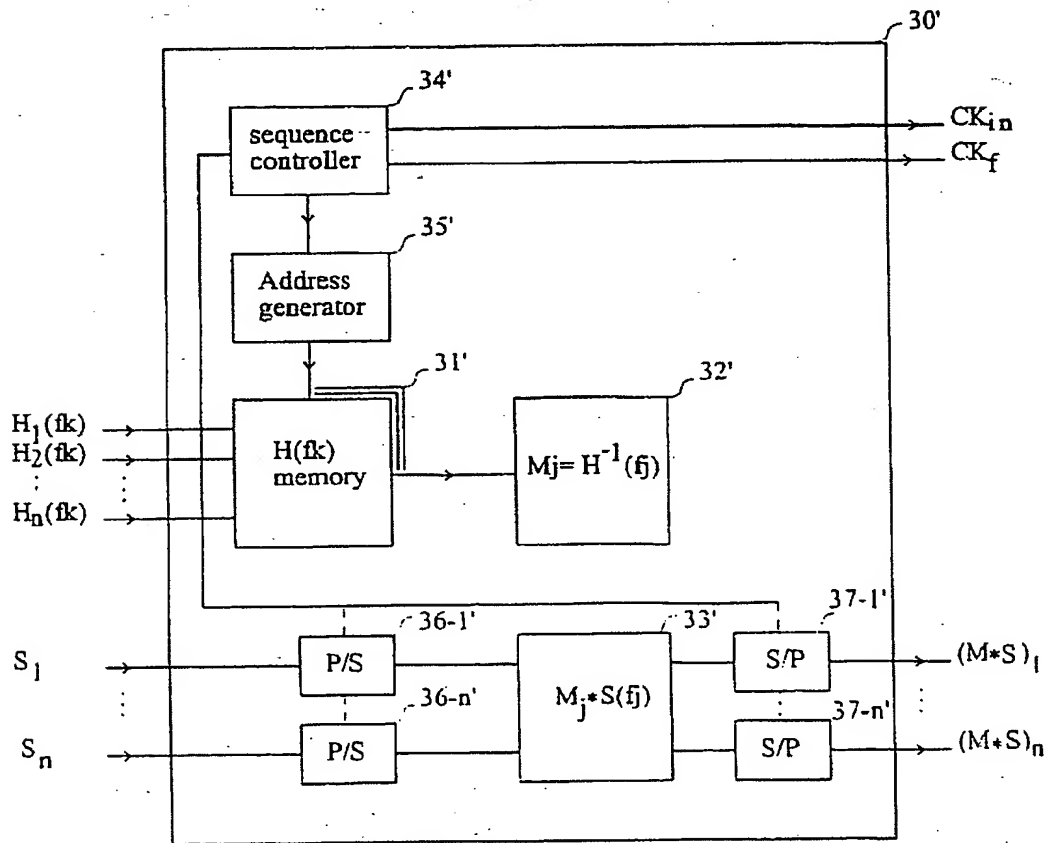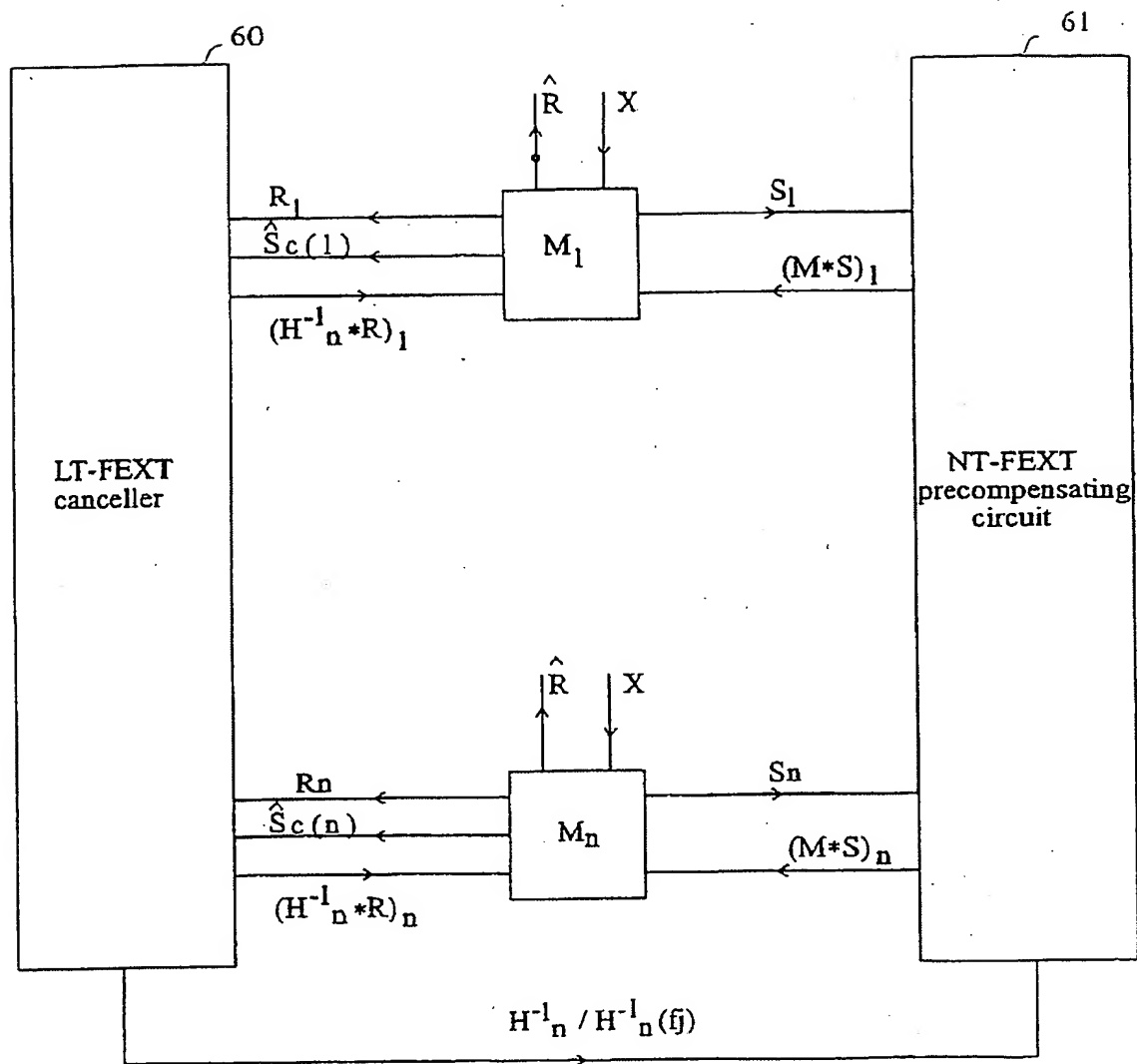$$(M*S)_n$$

$$H^{-1}_n \,/\, H^{-1}_n (fj)$$
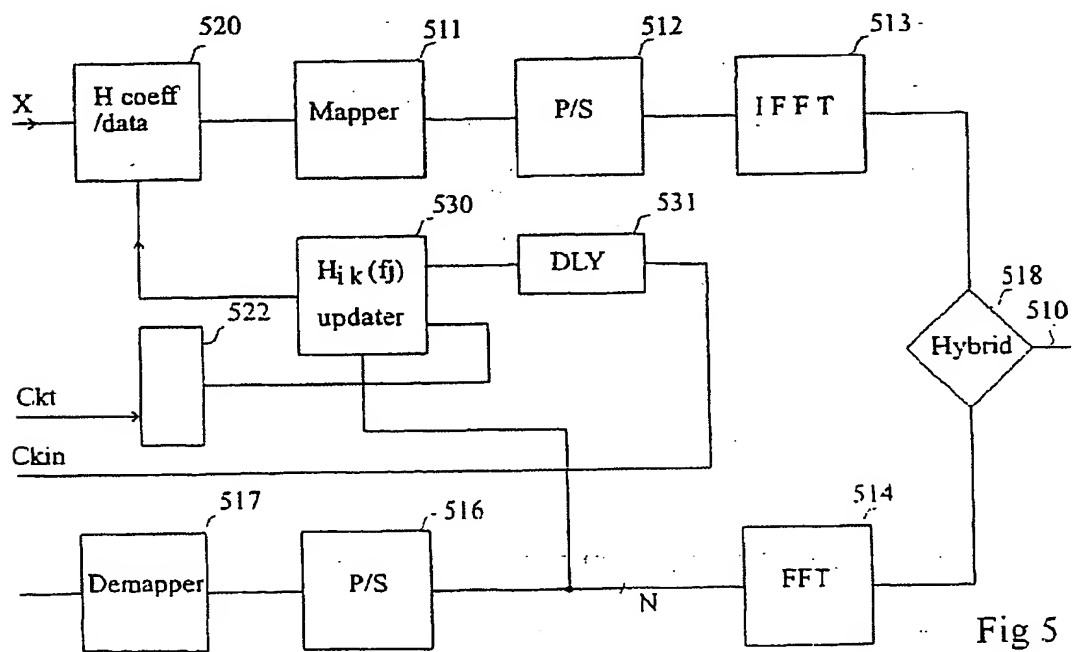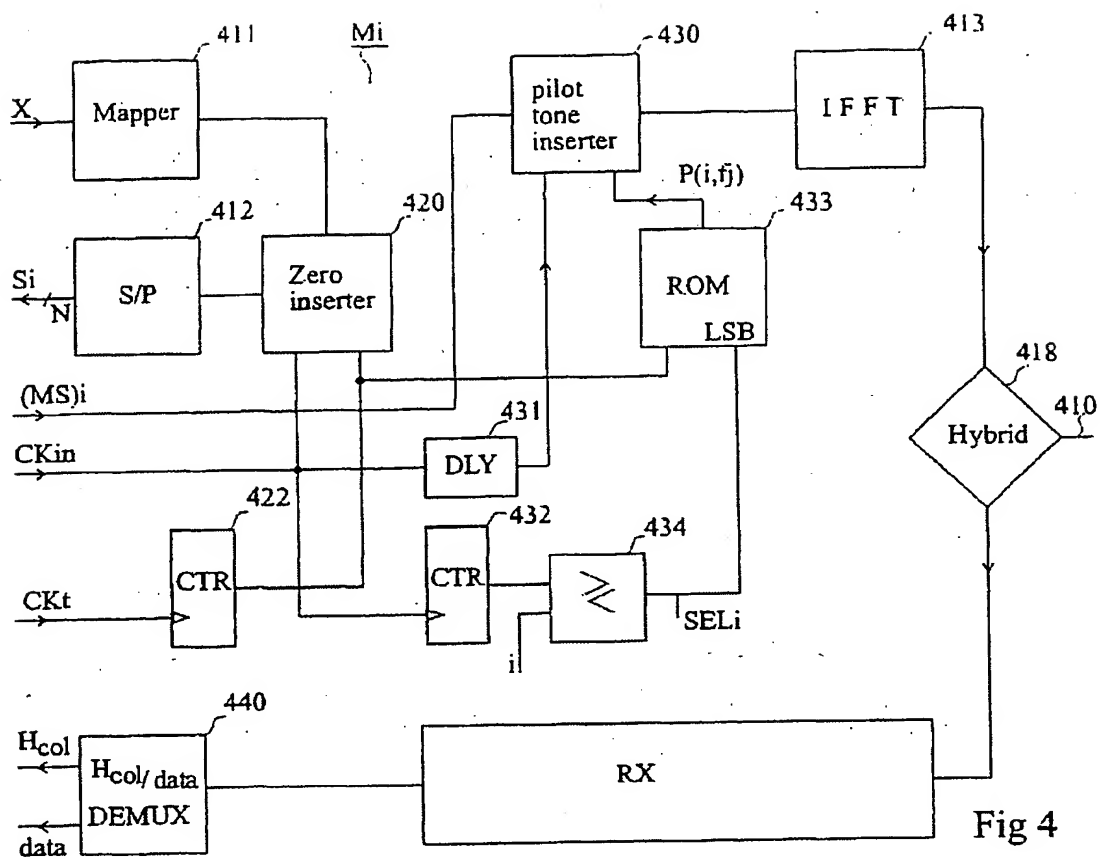
Fig 6

European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 99 41 0173

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	WO 94 18781 A (BELL COMMUNICATIONS RES) 18 August 1994 (1994-08-18) * page 9, line 11 - page 10, line 22 *	1-10	H04B3/32
A	US 5 181 198 A (LECHLEIDER JOSEPH W) 19 January 1993 (1993-01-19) * column 4, line 67 - column 6, line 44 *	1-10	
A,D	WO 97 06619 A (TELIA AB ;ISAKSSON MIKAEL (SE)) 20 February 1997 (1997-02-20) * page 2, line 28 - line 39 *	1-10	

TECHNICAL FIELDS
SEARCHED   (Int.Cl.7)

H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 February 2000	De Iulis, M

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ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 99 41 0173

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report
The members are as contained in the European Patent Office EDP file on
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24-02-2000

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9418781	A	18-08-1994	US	5511119 A	23-04-1996
US 5181198	A	19-01-1993	NONE		
WO 9706619	A	20-02-1997	EP SE	0883944 A 9502775 A	16-12-1998 05-02-1997

For more details about this annex see Official Journal of the European Patent Office. No 12/82

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